

CLAIMS

1. A worm reduction gear comprising a worm wheel, a worm shaft and an elastic body, wherein the elastic body applies an elastic force to the worm shaft in a direction towards the worm wheel.
2. A worm reduction gear according to claim 1, wherein the elastic body applies an elastic force to the worm shaft in a direction towards the worm wheel via a pre-load pad, and the worm wheel is fixed freely to an assist shaft, and opposite ends of the worm shaft are supported on the inside of a gear housing by a pair of bearings, and a worm provided in an intermediate portion of the worm shaft meshes with the worm wheel, and displacement of the pre-load pad in relation to a predetermined direction, is restricted by a guide face provided on the gear housing or on a member fixed to the gear housing, and a clearance between the pre-load and the guide face is either eliminated or reduced by elastic deformation of the pre-load pad itself based on an elastic force of the elastic body.
3. A worm reduction gear according to claim 1, wherein the elastic body applies an elastic force to the worm shaft in a direction towards the worm

wheel via a pre-load pad, and the worm wheel is fixed freely to an assist shaft, and opposite ends of the worm shaft are supported on the inside of a gear housing by a pair of bearings, and a worm provided in an intermediate portion of the worm shaft meshes with the worm wheel, and the pre-load pad comprises a pair of elements, and displacement of the pre-load pad in relation to a predetermined direction, is restricted by a guide face provided on the gear housing or on a member fixed to the gear housing, and a clearance between the pre-load pad and the guide face is either eliminated or reduced by movement of the pair of elements in a direction to separate from each other, based on an elastic force of the elastic body.

4. A worm reduction gear according to either one of claim 2 and claim 3, wherein a direction of possible displacement of the pre-load pad along the guide face is inclined with respect to a virtual plane containing the central axis of the worm shaft and meshing portion between the worm provided on the worm shaft and the worm wheel.

5. An electric power steering apparatus comprising: a steering shaft provided at a rear end portion thereof with a steering wheel; a pinion provided on a front end side of the steering shaft, a rack meshed with the

pinion or with a member supported on the pinion; a worm reduction gear according to any one of claim 2 through claim 4; an electric motor for rotatably driving the worm shaft; a torque sensor for detecting the direction and magnitude of a torque applied to the steering shaft or pinion; and a controller for controlling a drive status of the electric motor based on a signal input from the torque sensor, and the assist shaft is a member being the steering shaft, the pinion, or a sub-pinion meshing with the rack at a position separated from the pinion.

6. A worm reduction gear according to claim 1, wherein the elastic body is an elastic force applying device, the worm shaft is supported such as to permit rotation and oscillating displacement with respect to a gear housing, and a worm provided at an intermediate portion of the worm shaft is meshed with the worm wheel, and an oscillating central axis of the worm shaft is provided parallel to the central axis of the worm wheel at a position displaced towards the worm wheel side from the central axis of the worm shaft.

7. A worm reduction gear according to claim 6, wherein an axis parallel with the central axis of the worm wheel and passing through one point on a straight line which is parallel with the central axis of the worm shaft and

includes an intersection point of pitch circles of the worm of the worm shaft and the worm wheel, is made the oscillating central axis of the worm shaft.

8. A worm reduction gear according to either one of claim 6 and claim 7, wherein a bearing holder for supporting at least one of the pair of bearings which rotatably support opposite end portions of the worm shaft, is supported such as to permit oscillating displacement with respect to the gear housing.

9. A worm reduction gear according to any one of claim 6 through claim 8, wherein the oscillating central axis of the worm shaft is provided in relation to the axial direction of the worm shaft, between a bearing on an electric motor side of the pair of bearings rotatably supporting opposite end portions of the worm shaft and a meshing portion of the worm of the worm shaft and the worm wheel.

10. A worm reduction gear according to any one of claim 6 through claim 9, wherein the elastic force applying device for applying an elastic force to the worm shaft in a direction towards the worm wheel is provided on an opposite side to the oscillating central axis of the worm shaft in relation to the meshing portion of the worm of the worm shaft and the worm wheel.

11. A worm reduction gear according to any one of claim 6 through claim 10, wherein a bearing holder for supporting a bearing for rotatably supporting one end portion of the worm shaft, is supported in the gear housing such as to permit oscillating displacement by an oscillating axis, and an elastic member is provided between the gear housing and the oscillating axis, or between the bearing holder and the oscillating axis.

12. A worm reduction gear according to any one of claim 6 through claim 10, wherein a bearing holder for supporting a bearing for rotatably supporting one end portion of the worm shaft, is supported in the gear housing such as to permit oscillating displacement by an oscillating axis, and an elastic ring with at least one part being of an elastic member is provided between the gear housing and the oscillating axis, or between the bearing holder and the oscillating axis, and the rigidity of the elastic ring in relation to the radial direction of the oscillating axis of the worm shaft is made different around the circumferential direction.

13. A worm reduction gear according to any one of claim 6 through claim 9, wherein an elastic force applying device for applying an elastic force in a

direction towards the worm wheel to the worm shaft, is provided between the worm shaft and an electric motor rotating shaft.

14. A worm reduction gear according to any one of claim 6 through claim 9, wherein an elastic force applying device for applying an elastic force in a direction towards the worm wheel to the worm shaft, is provided between a bearing holder for supporting at least one of the pair of bearings rotatably supporting opposite end portions of the worm shaft, and the gear housing.

15. A worm reduction gear according to any one of claim 6 through claim 14, wherein an elastic member is provided between one of the pair of bearings supporting opposite end portions of the worm shaft, and which is separated from the oscillating central axis of the worm shaft, and the gear housing, to thereby enable oscillating displacement of the worm shaft with respect to the gear housing.

16. A worm reduction gear according to any one of claim 6 through claim 14, wherein a second elastic ring with at least one part being of an elastic member is provided between one of the pair of bearings supporting opposite end portions of the worm shaft, and which is separated from the oscillating

central axis of the worm shaft, and the gear housing, to thereby enable oscillating displacement of the worm shaft with respect to the gear housing, and the rigidity of this second elastic ring in relation to the direction of oscillating displacement of the worm shaft is made different to that in another direction.

17. A worm reduction gear according to either one of claim 15 and claim 16, wherein a stopper portion for restricting oscillating displacement of the worm shaft, is provided in the elastic member or the second elastic ring provided between the one bearing and the gear housing.

18. A worm reduction gear according to any one of claim 6 through claim 17, wherein a rotating shaft of an electric motor and the worm shaft are connected via an elastic member.

19. A worm reduction gear according to any one of claim 6 through claim 18, wherein grease is filled between the gear housing and a bearing holder for supporting at least one bearing of the pair of bearings which rotatably support opposite end portions of the worm shaft.

20. A worm reduction gear according to any one of claim 6 through claim 19, wherein a bearing holder for supporting at least one bearing of the pair of bearings which rotatably support opposite end portions of the worm shaft is made of magnesium alloy.

21. An electric power steering apparatus comprising: a steering shaft provided at a rear end portion thereof with a steering wheel; a pinion provided on a front end side of the steering shaft, a rack meshed with the pinion or with a member supported on the pinion; a worm reduction gear according to any one of claim 6 through claim 20; an electric motor for rotatably driving the worm shaft; a torque sensor for detecting the direction and magnitude of a torque applied to the steering shaft or pinion; and a controller for controlling a drive status of the electric motor based on a signal input from the torque sensor, and the worm wheel is fixed to a member being the steering shaft, the pinion, or a sub-pinion meshing with the rack at a position separated from the pinion.

22. A worm reduction gear according to claim 1, wherein the elastic body applies an elastic force to the worm shaft in a direction towards the worm wheel via a pre-load pad, and the worm wheel is fixed freely to an assist shaft,

and one end portion of the worm shaft is supported by a first bearing, and the other end portion is supported by a second bearing, inside a gear housing, and a worm provided in an intermediate portion of the worm shaft meshes with the worm wheel, and is able to oscillate around the first bearing, and an outer peripheral face and at least part of both axial side faces of the second bearing are covered by a synthetic resin shock-absorbing member fixed to the gear housing, and axial displacement of the second bearing with respect to the shock-absorbing member is restricted, and axial displacement of the worm shaft with respect to the pre-load pad and the second bearing is permitted.

23. A worm reduction gear according to claim 22, wherein the shock-absorbing member is one where notches are provided along the entire axial length in a part around the circumferential direction.

24. A worm reduction gear according to either one of claim 22 and claim 23, wherein for the second bearing, axial displacement of the second bearing with respect to the shock-absorbing member is prevented, and radial displacement of the second bearing with respect to the shock-absorbing member is permitted.

25. A worm reduction gear according to any one of claim 22 through claim 24, wherein an elastic member is provided between the shock-absorbing member and the gear housing, or between the shock-absorbing member and the second bearing.

26. A worm reduction gear according to any one of claim 22 through claim 25, wherein the shock-absorbing member comprises a pair of elements having a shape obtained by dividing the shock-absorbing member into two by a virtual plane containing the central axis of the shock-absorbing member.

27. A worm reduction gear according to claim 26, wherein the directions of the matching faces of the pair of elements are aligned with the direction wherein the elastic force is applied by the elastic body to the worm shaft.

28. An electric power steering apparatus comprising: a steering shaft provided at a rear end portion thereof with a steering wheel; a pinion provided on a front end side of the steering shaft; a rack meshed with the pinion or with a member supported on the pinion; a worm reduction gear according to any one of claim 22 through claim 27; an electric motor for rotatably driving the worm shaft; a torque sensor for detecting the direction

and magnitude of a torque applied to the steering shaft or pinion; and a controller for controlling a drive status of the electric motor based on a signal input from the torque sensor, and an assist shaft is a member being the steering shaft, the pinion, or a sub-pinion meshing with the rack at a position separated from the pinion.